

Arthritis & Rheumatism

An Official Journal of the American College of Rheumatology
www.arthritisrheum.org and wileyonlinelibrary.com

SPECIAL ARTICLE

Recommendations for the Nomenclature of IgG4-Related Disease and Its Individual Organ System Manifestations

John H. Stone,¹ Arezou Khosroshahi,¹ Vikram Deshpande,¹ John K. C. Chan,²
J. Godfrey Heathcote,³ Rob Aalberse,⁴ Atsushi Azumi,⁵ Donald B. Bloch,¹ William R. Brugge,¹
Mollie N. Carruthers,¹ Wah Cheuk,² Lynn Cornell,⁶ Carlos Fernandez-Del Castillo,¹
Judith A. Ferry,¹ David Forcione,¹ Günter Klöppel,⁷ Daniel L. Hamilos,¹ Terumi Kamisawa,⁸
Satomi Kasashima,⁹ Shigeyuki Kawa,¹⁰ Mitsuhiro Kawano,¹¹ Yasufumi Masaki,¹²
Kenji Notohara,¹³ Kazuichi Okazaki,¹⁴ Ji Kon Ryu,¹⁵ Takako Saeki,¹⁶ Dushyant Sahani,¹
Yasuharu Sato,¹⁷ Thomas Smyrk,⁶ James R. Stone,¹ Masayuki Takahira,¹¹
Hisanori Umehara,¹² George Webster,¹⁸ Motohisa Yamamoto,¹⁹ Eunhee Yi,⁶
Tadashi Yoshino,¹⁷ Giuseppe Zamboni,²⁰ Yoh Zen,²¹ and Suresh Chari⁶

Introduction

During the first decade of this century, recognition of a multi-organ system disease known as IgG4-related disease has grown. Serum IgG4 elevation (in some patients) and tissue infiltration with IgG4-positive plasma cells (in essentially all patients) (1–3) are com-

mon threads that connect a variety of seemingly disparate conditions observed previously in multiple organs (4). A highly characteristic histopathology and immunohistochemical staining pattern are found in the involved organs (5–7). Japanese investigators recently agreed on the name “IgG4-related disease” for this multifocal disorder (7).

An International Symposium on IgG4-Related

The International Symposium on IgG4-Related Disease was funded by the NIH (National Institute of Arthritis and Musculoskeletal and Skin Diseases grant R13-AR-061254) and by grants from Genentech, Biogen Idec, and Genzyme.

¹John H. Stone, MD, MPH, Arezou Khosroshahi, MD, Vikram Deshpande, MD, Donald B. Bloch, MD, William R. Brugge, MD, Mollie N. Carruthers, MD, Carlos Fernandez-Del Castillo, MD, Judith A. Ferry, MD, David Forcione, MD, Daniel L. Hamilos, MD, Dushyant Sahani, MD, James R. Stone, MD, PhD: Massachusetts General Hospital, Boston, Massachusetts; ²John K. C. Chan, MBBS, FRCPath, FRCPA, Wah Cheuk, MBBS: Queen Elizabeth Hospital, Hong Kong; ³J. Godfrey Heathcote, MB, PhD: Dalhousie University, Halifax, Nova Scotia, Canada; ⁴Rob Aalberse, PhD: University of Amsterdam, Amsterdam, The Netherlands; ⁵Atsushi Azumi, MD, PhD: Kobe University Graduate School of Medicine and Kobe Kaisei Hospital, Kobe, Japan; ⁶Lynn Cornell, MD, Thomas Smyrk, MD, Eunhee Yi, MD, Suresh Chari, MD: Mayo Clinic Foundation, Rochester, Minnesota; ⁷Günter Klöppel, MD: Technical University of Munich, Munich, Germany; ⁸Terumi Kamisawa, MD, PhD: Tokyo Metropolitan Komagome Hospital, Tokyo, Japan; ⁹Satomi Kasashima, MD, PhD: Kanazawa Medical Center, Kanazawa, Japan; ¹⁰Shigeyuki Kawa, MD, PhD: Shinshu University, Matsumoto, Japan; ¹¹Mitsuhiro Kawano, MD, PhD, Masayuki Takahira, MD, PhD: Kanazawa University Graduate School of Medical Sciences, Kanazawa, Japan; ¹²Yasufumi Masaki, MD, PhD, Hisanori Umehara, MD, PhD: Kana-

zawa Medical University, Uchinada, Japan; ¹³Kenji Notohara, MD, PhD: Kurashiki Central Hospital, Kurashiki, Japan; ¹⁴Kazuichi Okazaki, MD, PhD: Kansai Medical University, Hirakata, Japan; ¹⁵Ji Kon Ryu, MD: Seoul National University College of Medicine, Seoul, Republic of Korea; ¹⁶Takako Saeki, MD, PhD: Nagaoka Red Cross Hospital, Nagaoka, Japan; ¹⁷Yasuharu Sato, MD, Tadashi Yoshino, MD, PhD: Okayama University Graduate School of Medicine, Dentistry, and Pharmaceutical Sciences, Okayama, Japan; ¹⁸George Webster, MD, FRCP: University College London and University College London Hospitals, London, UK; ¹⁹Motohisa Yamamoto, MD, PhD: Sapporo Medical University School of Medicine, Sapporo, Japan; ²⁰Giuseppe Zamboni, MD: University of Verona, Verona, Italy; ²¹Yoh Zen, MD, PhD: King's College London and King's College Hospital, London, UK.

Dr. J. H. Stone has received consulting fees from Genentech and Biogen Idec (less than \$10,000 each). Dr. Brugge has received consulting fees, speaking fees, and/or honoraria from RedPath (less than \$10,000).

Address correspondence to John H. Stone, MD, MPH, Rheumatology Unit, Massachusetts General Hospital, 55 Fruit Street, Yawkey 2, Boston, MA 02114. E-mail: jhstone@partners.org.

Submitted for publication December 9, 2011; accepted in revised form June 19, 2012.

Disease was held in Boston, Massachusetts October 4–7, 2011 (http://www2.massgeneral.org/pathology/symposium/IgG4_related_systemic_dis.asp). The organizing committee, comprising 35 experts on IgG4-related disease from Japan, Korea, Hong Kong, the UK, Germany, Italy, The Netherlands, Canada, and the US, included clinicians, pathologists, radiologists, and basic scientists. This group represents broad subspecialty expertise in pathology, rheumatology, gastroenterology, allergy, immunology, nephrology, pulmonary medicine, oncology, ophthalmology, and surgery. Nomenclature was a specific focus of a portion of the symposium. Herein we report on the recommendations of the organizing committee related to terminology for the overall disease, with an emphasis on the individual organ system manifestations.

Description of IgG4-related disease and its unifying pathologic features

Certain clinical and pathologic features help define IgG4-related disease and distinguish it from its potential mimics. IgG4-related disease is a fibroinflammatory condition characterized by a tendency for formation of tumefactive lesions, a dense lymphoplasmacytic infiltrate rich in IgG4-positive plasma cells, storiform fibrosis, frequent but not invariable elevations of serum IgG4 levels, and a swift initial response to glucocorticoids provided that tissue fibrosis has not supervened.

IgG4-related disease is analogous in many ways to sarcoidosis, another systemic disease that affects virtually all organ systems, unified by a distinctive histologic appearance regardless of the organ involved. The pancreas was the first organ in which IgG4-related disease was identified, but the disease has now been described in virtually every organ system: the biliary tree, salivary glands, orbital tissues (e.g., lacrimal gland, extraocular muscles, and retrobulbar space), kidneys, lungs, lymph nodes, meninges, aorta, breast, prostate, thyroid gland, pericardium, retroperitoneum, and skin (5,6,8,9). The histopathologic features vary slightly across some organs, but, with the exception of IgG4-related lymphadenopathy and the membranous glomerulonephritis that is occasionally associated with this condition, the organ findings generally exhibit striking similarities. Increased numbers of infiltrating IgG4-bearing plasma cells are found within involved organs and are the sine qua non of the diagnosis. However, the diagnosis of IgG4-related disease cannot be made purely on the basis of staining for IgG4 (10). Rather, certain light microscopic features are also critical to the diagnosis (see below).

Table 1. Different names employed to refer to IgG4-related disease

| Name | Ref. |
|---|------|
| IgG4-related disease | 25 |
| IgG4-associated disease | 23 |
| IgG4-related systemic disease | 26 |
| IgG4-related sclerosing disease | 16 |
| IgG4-related systemic sclerosing disease | 42 |
| IgG4-related autoimmune disease | 4 |
| Hyper-IgG4 disease | 43 |
| IgG4-positive multiorgan lymphoproliferative syndrome | 44 |
| Systemic IgG4-related plasmacytic syndrome (SIPS) | 45 |
| IgG4 syndrome | 46 |

Existing terminology for multifocal disease and proposed terminology

We are aware of no fewer than 10 alternative names for IgG4-related disease (Table 1). The multi-system nature of the condition and the fact that many organ manifestations can have multiple potential names compound the confusion in the literature (Table 2). As noted above, Japanese investigators have reached a consensus to refer to this newly emerged disease as IgG4-related disease (7), specifically selecting this term over alternatives such as “IgG4-related systemic disease,” “IgG4-related sclerosing disease,” and “IgG4-positive multiorgan lymphoproliferative syndrome.”

The issue of naming the disease after IgG4 was debated at the symposium. Because of many unresolved questions regarding the role of IgG4 in pathogenesis and the use of serum concentrations as a biomarker for the disease (see below), reservations were expressed by some experts about naming the disease after IgG4 without qualifications. However, recognizing that efforts to “speak the same language” are important in facilitating collaboration and disseminating information about

Table 2. Names of previously recognized conditions that comprise or may comprise parts of the IgG4-related disease spectrum

| |
|--|
| Mikulicz disease |
| Küttner tumor |
| Riedel thyroiditis |
| Eosinophilic angiocentric fibrosis |
| Multifocal fibrosclerosis |
| Lymphoplasmacytic sclerosing pancreatitis/ autoimmune pancreatitis |
| Inflammatory pseudotumor |
| Fibrosing mediastinitis |
| Sclerosing mesenteritis |
| Retroperitoneal fibrosis (Ormond disease) |
| Periaortitis/periarteritis |
| Inflammatory aortic aneurysm |
| Cutaneous pseudolymphoma |
| Idiopathic hypertrophic pachymeningitis |
| Idiopathic tubulointerstitial nephritis |
| Idiopathic hypocomplementemic tubulointerstitial nephritis with extensive tubulointerstitial deposits |
| Idiopathic cervical fibrosis |

this newly recognized condition more widely, the organizing committee for the 2011 International Symposium on IgG4-Related Disease endorsed the consensus name chosen by the Japanese group. The organizing committee acknowledged that much remains unknown about the behavior of the IgG4 molecule *in vivo*, the pathways through which this immunoglobulin participates in the disease, and whether or not the role of IgG4 is primary or secondary. In time, discoveries pertaining to the etiology and pathophysiology of the condition may suggest a name that is more appropriate. For the present, the term IgG4-related disease recognizes aptly the ubiquity of IgG4 within involved organs. This fact, not the frequency with which patients have increased serum IgG4 concentrations, is the fundamental basis for using this term in the name of the disease.

Individual organ system manifestations: existing terms and suggested nomenclature

Several eponymic conditions known for decades, or even in some cases for more than a century, are now identified as part of the IgG4-related disease spectrum (Table 2). Some of these eponyms have been applied loosely and imprecisely, leading to confusion and uncertainty about the precise clinical syndromes to which they refer. Now that there is evidence of a larger, systemic disease context for these disorders, it is appropriate that the eponyms be replaced in favor of terms that offer more information about particular pathophysiologic mechanisms and patterns of disease pathology.

Agreement upon the consensus term IgG4-related disease facilitates a consistent nomenclature whereby individual organ involvement can be referred to in a style that employs “IgG4-related-” as a prefix, regardless of the organ system affected. As examples, type 1 autoimmune pancreatitis (AIP), now firmly entrenched in the gastroenterology literature, might be termed “type 1 AIP (IgG4-related pancreatitis).” Similarly, chronic sclerosing sialadenitis (sometimes termed a Küttner tumor when it involves the submandibular gland) might be called “IgG4-related sialadenitis” or “IgG4-related submandibular gland disease.” Such nomenclature underscores the belief that the same fundamental pathophysiologic processes are operative across organ systems in this disease, regardless of whether the role of IgG4 is viewed as primary or secondary.

Specific recommendations for IgG4-related organ system nomenclature

The recommendations of the organizing committee are shown in Table 3. Some potentially problematic areas are discussed below.

“Related” versus “associated.” The terms “related” and “associated,” both used in the medical literature in the context of this disease, are intended to convey the fact that IgG4-related disease is linked in some manner to IgG4-bearing plasma cells in tissue. We prefer the term “related” because it echoes the consensus name for the overall condition—IgG4-related disease—and has been used more consistently in the medical literature.

Pancreas. The pancreatic manifestation of IgG4-related disease was termed “autoimmune pancreatitis” in the mid-1990s (11), before the entity of IgG4-related disease had been conceptualized. The basis for considering this pancreatic condition to be autoimmune has not been established firmly, and no autoantibody has been identified consistently. AIP has since been divided into two types—type 1 and type 2—which share certain clinical similarities but are vastly different in terms of pathology and extrapancreatic features (12–14). Type 1 AIP is regarded as a prototypical organ manifestation of IgG4-related disease, which can occur alone or either simultaneously or metachronously with other organ complications. In contrast, type 2 AIP is not part of the IgG4-related disease spectrum and appears to be a disease of its own (15).

Over time, we anticipate that the term “type 1 AIP” might be replaced entirely by “IgG4-related pancreatitis.” Because type 1 AIP is widely accepted among gastroenterologists and pancreatic surgeons now, however, we propose adding “IgG4-related pancreatitis” in parentheses, *i.e.*, type 1 AIP (IgG4-related pancreatitis). This serves at least two purposes: 1) education of the broader medical community about the relationship between IgG4-related disease and this subset of pancreatic disease, and 2) avoidance of the issue of what to call type 2 AIP if type 1 AIP were removed entirely from the nomenclature.

Bile ducts. IgG4-related disease accounts for a subset of patients previously considered to have primary sclerosing cholangitis (16). Distinguishing between the primary and IgG4-related forms of sclerosing cholangitis is essential (but not always possible) because of the significant differences in treatment responses observed in these two conditions (17). At this time, it is unclear if patients with isolated biliary disease and elevated serum concentrations of IgG4 who meet imaging and clinical criteria for primary sclerosing cholangitis actually have IgG4-related disease.

Gastroenterologists and gastrointestinal pathologists on the organizing committee emphasized the importance of including “sclerosing” in the name of IgG4-related biliary tract disease as a means of linking this

Table 3. Preferred nomenclature for individual organ manifestations of IgG4-related disease

| Organ system/tissue | Preferred name |
|--|--|
| Pancreas | Type 1 autoimmune pancreatitis (IgG4-related pancreatitis) |
| Eye | IgG4-related ophthalmic disease is the general term for the periocular manifestations of this disease. There are several subsets, outlined below. |
| Lacrimal glands | IgG4-related dacryoadenitis |
| Orbital soft tissue (orbital inflammatory pseudotumor) | IgG4-related orbital inflammation (or IgG4-related orbital inflammatory pseudotumor) |
| Extraocular muscle disease | IgG4-related orbital myositis |
| Orbit with involvement of multiple anatomic structures | IgG4-related pan-orbital inflammation (includes lacrimal gland disease, extraocular muscle involvement, and other potential intraorbital complications) |
| Salivary glands (parotid and submandibular glands) | IgG4-related sialadenitis or, more specifically, IgG4-related parotitis or IgG4-related submandibular gland disease |
| Pachymeninges | IgG4-related pachymeningitis |
| Hypophysis | IgG4-related hypophysitis |
| Thyroid (Riedel thyroiditis) | IgG4-related thyroid disease |
| Aorta | IgG4-related aortitis/periaortitis |
| Arteries | IgG4-related periarteritis |
| Mediastinum | IgG4-related mediastinitis |
| Retroperitoneum | IgG4-related retroperitoneal fibrosis |
| Mesentery | IgG4-related mesenteritis |
| Skin | IgG4-related skin disease |
| Lymph node | IgG4-related lymphadenopathy |
| Bile ducts | IgG4-related sclerosing cholangitis |
| Gallbladder | IgG4-related cholecystitis |
| Liver | IgG4-related hepatopathy (refers to liver involvement that is distinct from biliary tract involvement) |
| Lung | IgG4-related lung disease |
| Pleura | IgG4-related pleuritis |
| Pericardium | IgG4-related pericarditis |
| Kidney | IgG4-related kidney disease. The specific renal complications should be termed tubulointerstitial nephritis secondary to IgG4-related disease and membranous glomerulonephritis secondary to IgG4-related disease. Involvement of the renal pelvis should be termed IgG4-related renal pyelitis. |
| Breast | IgG4-related mastitis |
| Prostate | IgG4-related prostatitis |

condition with, but still distinguishing it from, primary sclerosing cholangitis. Thus, we propose that IgG4-related disease of the biliary tree be termed “IgG4-related sclerosing cholangitis,” even though residual “sclerosis” of the bile ducts is not always observed after glucocorticoid therapy in IgG4-related disease.

Mikulicz disease/syndrome. The term “Mikulicz disease” has been used to denote idiopathic bilateral, painless, and symmetric swelling of the lacrimal, parotid, and submandibular glands, often in the context of IgG4-related disease (18). However, “Mikulicz syndrome” can be caused by many different conditions and, indeed, the true diagnosis of the index patient described by Mikulicz is not clear (19). Some evidence suggests that the patient had an extranodal marginal zone lymphoma of the mucosa-associated lymphoid tissue type rather than IgG4-related disease (20). Moreover, the term Mikulicz disease has been applied inconsistently and even incorrectly for decades, sometimes being regarded as part of the spectrum of Sjögren’s syndrome (SS) (21).

Thus, it seems appropriate to discard “Mikulicz disease” when referring to patients with involvement of the lacrimal, parotid, and submandibular glands and to instead use terms that refer to specific individual organ systems, i.e., “IgG4-related dacryoadenitis” for those with lacrimal gland disease, “IgG4-related parotitis” for those with parotid disease, and “IgG4-related sialadenitis” or “IgG4-related submandibular gland disease” for those with submandibular gland involvement.

Küttner tumor. A Küttner tumor refers to enlargement of the submandibular gland, sometimes as a result of stones in the Wharton duct (22). The use of the term by pathologists has been overly broad, often without full consideration of the underlying cause (or in the absence of knowledge of IgG4-related disease). A significant proportion of cases of “Küttner tumor” represent manifestations of IgG4-related disease. Important pathologic differences can be demonstrated between Küttner tumors associated with sialodocholithiasis and submandibular gland enlargement caused by IgG4-

related disease (23). For example, the fibrotic lesions that occur within the lesions of IgG4-related sialadenitis are characterized by intense inflammation within the areas of fibrosis, in contrast to the bland fibrotic lesions observed in Küttner tumors caused by salivary duct stones. Another important clinical difference is that IgG4-related sialadenitis is more likely to affect both submandibular glands.

Many patients with IgG4-related submandibular gland disease have been diagnosed in the past as having primary SS. In this regard, it is worth noting that patients with primary SS rarely (if ever) have isolated submandibular gland enlargement to the degree observed in IgG4-related disease. Primary SS is far more likely to involve the parotid glands disproportionately to the submandibular glands or to involve both of these glands together (24). IgG4-related disease, in contrast to primary SS, is not associated with antibodies to either the Ro/SSA or the La/SSB antigen (18).

Ophthalmic disease. IgG4-related disease is now recognized to be an important cause of “idiopathic” orbital inflammation and a major component of the differential diagnosis that includes lymphoma, granulomatosis with polyangiitis (Wegener’s), Graves orbitopathy, and other conditions (25). IgG4-related disease must be excluded before the label of “idiopathic” is applied. (As discussed below, serum IgG4 measurement is not sufficient to exclude IgG4-related disease if the concentration is normal, nor does an elevated concentration confirm the diagnosis.) We recognize that in some patients with IgG4-related ophthalmic disease the process extends beyond the orbit to include, for example, part of the course of the trigeminal nerve (26,27). Hence, when referring to eye involvement in general, the broader term “IgG4-related ophthalmic disease” is proposed instead of “IgG4-related orbital disease.”

Although IgG4-related ophthalmic disease is the recommended general term for disease involving the lacrimal glands, extraocular muscles, and other portions of the orbit (and beyond), it is preferable to refer to IgG4-related disease involvement of the ophthalmic region by specific terms, when possible. Thus, lacrimal gland involvement should be termed “IgG4-related dacryoadenitis,” and IgG4-related disease affecting the extraocular muscles should be called “IgG4-related orbital myositis.” The proposed term for orbital pseudotumor occurring in the context of IgG4-related disease is “IgG4-related orbital inflammation.” Generalized IgG4-related orbital disease that affects multiple anatomic structures of the orbit simultaneously should be termed “IgG4-related pan-orbital inflammation.”

Thyroid. Riedel thyroiditis has long been known to be associated with multifocal fibrosclerosis (28).

Most cases of multifocal fibrosclerosis, in turn, are now recognized to be multi-organ system manifestations of IgG4-related disease. Riedel thyroiditis has been proven by immunohistochemical staining to be part of the IgG4-related disease spectrum (29). We propose that the term “IgG4-related thyroid disease” be used now in lieu of Riedel thyroiditis. Whether the “fibrosing variant” of Hashimoto thyroiditis is part of the IgG4-related disease spectrum remains to be clarified in studies of additional cases.

Kidney. Tubulointerstitial nephritis (TIN) is the most common renal feature of IgG4-related disease, but glomerular disease (e.g., membranous nephritis) has also been described (30). The TIN associated with IgG4-related disease can be differentiated histopathologically and immunohistochemically from TIN due to other causes (31,32). Further studies of the relationships between the membranous glomerulonephritis that sometimes occurs in IgG4-related disease and the “idiopathic” form of this disease are needed, because this issue is still controversial. However, we propose referring to both TIN and membranous glomerulopathy that occur in the setting of IgG4-related disease as “IgG4-related kidney disease.” For cases in which membranous glomerulonephritis is the sole kidney lesion present and TIN is not evident, avoidance of the term IgG4-related kidney disease is appropriate at the present time.

The membranous glomerulonephritis of IgG4-related disease appears to have a different pathophysiology from the rest of IgG4-related disease. In IgG4-related disease, membranous glomerulonephritis is probably secondary to immune complex deposition rather than the usual destructive inflammatory process that characterizes other organ involvement in this condition. The membranous glomerulonephritis of IgG4-related disease is a different disorder from “idiopathic” membranous glomerulonephritis, which is characterized by antibodies to the phospholipase A₂ receptor (33). It is worth noting, however, that the anti-phospholipase A₂ receptor antibodies in idiopathic membranous glomerulonephropathy are principally of the IgG4 subclass.

Several types of radiologically evident lesions within the kidney have been described in IgG4-related disease, including diffuse renal enlargement, focal renal masses, and thickening of the renal pelvis. These lesions, which occur in association with other manifestations of IgG4-related disease in the majority of cases, often resolve with glucocorticoid treatment and are rarely biopsied if the diagnosis has been established in another organ. We propose that such radiologically identified renal lesions also be regarded as IgG4-related kidney disease, provided they occur in the setting of other organ

involvement that has been confirmed histopathologically.

Aorta. IgG4-related disease that involves the aorta has a predilection for the adventitia and periaortic tissue (34–36). However, the disease also involves the media, making it by definition an aortitis rather than a periaortitis (35). We propose the term “IgG4-related aortitis/periaortitis” for this condition, to reflect the anatomic extent of inflammation. IgG4-related periaortitis may exhibit some overlap with IgG4-related retroperitoneal fibrosis. Additional studies of medium-sized arteries and veins in IgG4-related disease are needed, but the term “IgG4-related periarteritis” appears appropriate at this time.

Notes of caution: problems with the use of IgG4 as a biomarker of IgG4-related disease

The adoption of “IgG4” into the name of this condition reflects the ubiquity of IgG4-bearing plasma cells in the tissues of involved organs. It is increasingly clear, however, that serum concentrations of IgG4 are unreliable as diagnostic markers of IgG4-related disease, as indicators of disease activity, and as measures of response to treatment. Approximately 20–40% of patients with biopsy-proven IgG4-related disease have normal serum IgG4 concentrations at the time of diagnosis, even before the institution of therapy (37,38). In addition, a varying proportion (3–7%) of both healthy controls and disease controls have elevated serum IgG4 levels, though it is uncommon for levels in controls to be more than twice the upper limit of normal (39,40).

The number of IgG4-positive plasma cells in tissues may also be misleading because the infiltration with IgG4-positive cells can be observed in conditions other than IgG4-related disease (10). A consensus statement on the pathology of IgG4-related disease emphasizes that certain light microscopy features, particularly storiform fibrosis, obliterative phlebitis, mild to moderate eosinophilia, and germinal center formation, are also critical to the diagnosis (41). Inclusion of IgG4 in the terminology of the disease should not lead clinicians to make the diagnosis solely based on serum IgG4 concentrations or tissue-infiltrating IgG4-positive plasma cells. Rather, the diagnosis of IgG4-related disease must be predicated upon specific histopathologic findings and then confirmed by tissue immunostaining, all in the setting of an appropriate clinical context.

Conclusions

IgG4-related disease is a recently recognized multi-organ system condition with pathologic features

that are consistent across a wide range of organ systems. This condition unifies a large number of medical diagnoses previously regarded as being confined to single organ systems. The precise links between the full histopathologic picture of IgG4-related disease, the frequent serum elevations of IgG4 levels, and the finding of increased IgG4-bearing plasma cells in tissue remain to be ascertained fully. The use of a shared nomenclature will facilitate efforts to better understand this emerging condition and its larger implications with regard to the immune system.

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be published. Dr. J. H. Stone had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. J. H. Stone, Khosroshahi, Deshpande, Chan, Heathcote, Bloch, Brugge, Carruthers, Cheuk, Fernandez-Del Castillo, Hamilos, Kamisawa, Kawa, Kawano, Masaki, Okazaki, Saeki, Sahani, Sato, J. R. Stone, Umehara, Yamamoto, Yi, Yoshino, Zamboni, Zen, Chari.

Acquisition of data. J. H. Stone, Khosroshahi, Deshpande, Chan, Bloch, Carruthers, Cheuk, Cornell, Ferry, Kamisawa, Kasashima, Kawano, Masaki, Okazaki, Ryu, Saeki, Sato, J. R. Stone, Takahira, Umehara, Yamamoto, Yi, Yoshino.

Analysis and interpretation of data. J. H. Stone, Khosroshahi, Deshpande, Chan, Aalberse, Azumi, Bloch, Carruthers, Cheuk, Cornell, Forcione, Klöppel, Kamisawa, Kasashima, Kawa, Kawano, Notohara, Okazaki, Ryu, Saeki, Sahani, Sato, Smyrk, J. R. Stone, Takahira, Umehara, Webster, Yamamoto, Yi, Yoshino.

REFERENCES

1. Kamisawa T, Okamoto A, Funata N. Clinicopathological features of autoimmune pancreatitis in relation to elevation of serum IgG4. *Pancreas* 2005;31:28–31.
2. Zhang L, Notohara K, Levy MJ, Chari ST, Smyrk TC. IgG4-positive plasma cell infiltration in the diagnosis of autoimmune pancreatitis. *Mod Pathol* 2007;20:23–8.
3. Hamano H, Kawa S, Horiuchi A, Unno H, Furuya N, Akamatsu T, et al. High serum IgG4 concentrations in patients with sclerosing pancreatitis. *N Engl J Med* 2001;344:732–8.
4. Kamisawa T, Funata N, Hayashi Y, Eishi Y, Koike M, Tsuruta K, et al. A new clinicopathological entity of IgG4-related autoimmune disease. *J Gastroenterol* 2003;38:982–4.
5. Khosroshahi A, Stone JH. A clinical overview of IgG4-related systemic disease. *Curr Opin Rheumatol* 2011;23:57–66.
6. Cheuk W, Chan JK. IgG4-related sclerosing disease: a critical appraisal of an evolving clinicopathologic entity. *Adv Anat Pathol* 2010;17:303–32.
7. Umehara H, Okazaki K, Masaki Y, Kawano M, Yamamoto M, Saeki T, et al, and the Research Program for Intractable Disease by Ministry of Health, Labor and Welfare (MHLW) Japan G4 team. A novel clinical entity, IgG4-related disease (IgG4RD): general concept and details. *Mod Rheumatol* 2012;22:1–14.
8. Zhang L, Smyrk TC. Autoimmune pancreatitis and IgG4-related systemic diseases. *Int J Clin Exp Pathol* 2010;3:491–504.
9. Hamano H, Kawa S, Ochi Y, Unno H, Shiba N, Wajiki M, et al. Hydronephrosis associated with retroperitoneal fibrosis and sclerosing pancreatitis. *Lancet* 2002;359:1403–4.
10. Strehl JD, Hartmann A, Agaimy A. Numerous IgG4-positive

- plasma cells are ubiquitous in diverse localised non-specific chronic inflammatory conditions and need to be distinguished from IgG4-related systemic disorders. *J Clin Pathol* 2011;64:237–43.
11. Yoshida K, Toki F, Takeuchi T, Watanabe S, Shiratori K, Hayashi N. Chronic pancreatitis caused by an autoimmune abnormality: proposal of the concept of autoimmune pancreatitis. *Dig Dis Sci* 1995;40:1561–8.
 12. Deshpande V, Gupta R, Sainani N, Sahani DV, Virk R, Ferrone C, et al. Subclassification of autoimmune pancreatitis: a histologic classification with clinical significance. *Am J Surg Pathol* 2011;35:26–35.
 13. Notohara K, Burgart LJ, Yadav D, Chari S, Smyrk TC. Idiopathic chronic pancreatitis with periductal lymphoplasmacytic infiltration: clinicopathologic features of 35 cases. *Am J Surg Pathol* 2003;27:1119–27.
 14. Zamboni G, Luttges J, Capelli P, Frulloni L, Cavallini G, Pederzoli P, et al. Histopathological features of diagnostic and clinical relevance in autoimmune pancreatitis: a study on 53 resection specimens and 9 biopsy specimens. *Virchows Arch* 2004;445:552–63.
 15. Kloppel G, Detlefsen S, Chari ST, Longnecker DS, Zamboni G. Autoimmune pancreatitis: the clinicopathological characteristics of the subtype with granulocytic epithelial lesions. *J Gastroenterol* 2010;45:787–93.
 16. Kamisawa T. IgG4-related sclerosing disease. *Intern Med* 2006;45:125–6.
 17. Ghazale A, Chari ST, Zhang L, Smyrk TC, Takahashi N, Levy MJ, et al. Immunoglobulin G4-associated cholangitis: clinical profile and response to therapy. *Gastroenterology* 2008;134:706–15.
 18. Yamamoto M, Takahashi H, Ohara M, Suzuki C, Naishiro Y, Yamamoto H, et al. A new conceptualization for Mikulicz's disease as an IgG4-related plasmacytic disease. *Mod Rheumatol* 2006;16:335–40.
 19. Von Mikulicz-Radecki J. Concerning a peculiar symmetrical disease of the lacrymal and salivary glands. *Med Classics* 1937;2:165–86.
 20. Ihrlar S, Harrison JD. Mikulicz's disease and Mikulicz's syndrome: analysis of the original case report of 1892 in the light of current knowledge identifies a MALT lymphoma. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;100:334–9.
 21. Morgan WS, Castleman B. A clinicopathologic study of Mikulicz's disease. *Am J Pathol* 1953;29:471–503.
 22. Kuttner H. Über entzündliche Tumoren der submaxillären Speicheldrüse. *Beitr Klin Chir* 1896;15:815–34.
 23. Geyer JT, Ferry JA, Harris NL, Stone JH, Zukerberg LR, Lauwers GY, et al. Chronic sclerosing sialadenitis (Küttner tumor) is an IgG4-associated disease. *Am J Surg Pathol* 2010;34:202–10.
 24. Bloch KJ, Buchanan WW, Wohl MJ, Bunim JJ. Sjögren's syndrome: a clinical, pathological, and serological study of sixty-two cases. *Medicine (Baltimore)* 1965;44:187–231.
 25. Sato Y, Ohshima K, Ichimura K, Sato M, Yamadori I, Tanaka T, et al. Ocular adnexal IgG4-related disease has uniform clinicopathology. *Pathol Int* 2008;58:465–70.
 26. Khosroshahi A, Bloch DB, Deshpande V, Stone JH. Rituximab therapy leads to rapid decline of serum IgG4 levels and prompt clinical improvement in IgG4-related systemic disease. *Arthritis Rheum* 2010;62:1755–62.
 27. Wallace ZS, Khosroshahi A, Jakobiec FA, Deshpande V, Hatton MP, Ritter J, et al. IgG4-related systemic disease as a cause of "idiopathic" orbital inflammation, including orbital myositis, and trigeminal nerve involvement. *Surv Ophthalmol* 2012;57:26–33.
 28. Comings DE, Skubi KB, van Eyes J, Motulsky AG. Familial multifocal fibrosclerosis: findings suggesting that retroperitoneal fibrosis, mediastinal fibrosis, sclerosing cholangitis, Riedel's thyroiditis, and pseudotumor of the orbit may be different manifestations of a single disease. *Ann Intern Med* 1967;66:884–92.
 29. Dahlgren M, Khosroshahi A, Nielsen GP, Deshpande V, Stone JH. Riedel's thyroiditis and multifocal fibrosclerosis are part of the IgG4-related systemic disease spectrum. *Arthritis Care Res (Hoboken)* 2010;62:1312–8.
 30. Saeki T, Nishi S, Imai N, Ito T, Yamazaki H, Kawano M, et al. Clinicopathological characteristics of patients with IgG4-related tubulointerstitial nephritis. *Kidney Int* 2010;78:1016–23.
 31. Nishi S, Imai N, Yoshida K, Ito Y, Saeki T. Clinicopathological findings of immunoglobulin G4-related kidney disease. *Clin Exp Nephrol* 2011;15:810–9.
 32. Raissian Y, Nasr SH, Larsen CP, Colvin RB, Smyrk TC, Takahashi N, et al. Diagnosis of IgG4-related tubulointerstitial nephritis. *J Am Soc Nephrol* 2011;22:1343–52.
 33. Beck LH Jr, Bonegio RG, Lambeau G, Beck DM, Powell DW, Cummins TD, et al. M-type phospholipase A₂ receptor as target antigen in idiopathic membranous nephropathy. *N Engl J Med* 2009;2;361:11–21.
 34. Stone JH, Khosroshahi A, Hilgenberg A, Spooner A, Isselbacher EM, Stone JR. IgG4-related systemic disease and lymphoplasmacytic aortitis. *Arthritis Rheum* 2009;60:3139–45.
 35. Kasashima S, Zen Y, Kawashima A, Endo M, Matsumoto Y, Kasashima F, et al. A clinicopathologic study of immunoglobulin G4-related sclerosing disease of the thoracic aorta. *J Vasc Surg* 2010;52:1587–95.
 36. Stone JH, Khosroshahi A, Deshpande V, Stone JR. IgG4-related systemic disease accounts for a significant proportion of thoracic lymphoplasmacytic aortitis cases. *Arthritis Care Res (Hoboken)* 2010;62:316–22.
 37. Kamisawa T, Takuma K, Tabata T, Inaba Y, Egawa N, Tsuruta K, et al. Serum IgG4-negative autoimmune pancreatitis. *J Gastroenterol* 2011;46:108–16.
 38. Frulloni L, Lunardi C. Serum IgG4 in autoimmune pancreatitis: a marker of disease severity and recurrence? *Dig Liver Dis* 2011;43:674–5.
 39. Sadler R, Chapman RW, Simpson D, Soonawalla ZF, Waldegrave EL, Burden JM, et al. The diagnostic significance of serum IgG4 levels in patients with autoimmune pancreatitis: a UK study. *Eur J Gastroenterol Hepatol* 2011;23:139–45.
 40. Oseini AM, Chaiteerakij R, Shire AM, Ghazale A, Kaiya J, Moser CD, et al. Utility of serum immunoglobulin G4 in distinguishing immunoglobulin G4-associated cholangitis from cholangiocarcinoma. *Hepatology* 2011;54:940–8.
 41. Deshpande V, Zen Y, Chan JK, Yi EE, Sato Y, Yoshino T, et al. Consensus statement on pathology of IgG4-related disease. *Mod Pathol* 2012. E-pub ahead of print.
 42. Bateman AC, Deheragoda MG. IgG4-related systemic sclerosing disease—an emerging and under-diagnosed condition. *Histopathology* 2009;55:373–83.
 43. Neild GH, Rodriguez-Justo M, Wall C, Connolly JO. Hyper-IgG4 disease: report and characterisation of a new disease. *BMC Med* 2006;4:23.
 44. Masaki Y, Dong L, Kurose N, Kitagawa K, Morikawa Y, Yamamoto M, et al. Proposal for a new clinical entity, IgG4-positive multiorgan lymphoproliferative syndrome: analysis of 64 cases of IgG4-related disorders. *Ann Rheum Dis* 2009;68:1310–5.
 45. Yamamoto M, Takahashi H, Naishiro Y, Isshiki H, Ohara M, Suzuki C, et al. Mikulicz's disease and systemic IgG4-related plasmacytic syndrome (SIPS). *Nihon Rinsho Meneki Gakkai Kaishi* 2008;31:1–8.
 46. Fragoulis GE, Moutsopoulos HM. IgG4 syndrome: old disease, new perspective. *J Rheumatol* 2010;37:1369–70.